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AUTHOR	Lee, Lung-Sheng Steven
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ABSTRACT

In regard to teaching problem solving in technology education, three questions are posed: (1) Why should problem solving be the intent and content of technology education? (2) How can a problem-solving approach be incorporated into technology education programs? and (3) What must be done to implement a problem-solving approach in the junior high school technology education programs in Taiwan? In answer to the first question, problem-solving has often been equated with thinking and learning skills, can be taught and that technology is a human adaptive system, technology education should urge problem-solving as its intent to enable students to become practical problem solvers and as its content to integrate a problem-solving process throughout all the instructional content. It has also been found that more research and development efforts should be made to comprehend how to employ a problem-solving approach effectively in technology education programs. In addition, a study completed in Taiwan found the following: there is an obvious distinction between the key instructional strategies in the current curriculum standard and the new proposed curriculum standard; the instructional strategies that current teachers actually use (usually lecture-demonstration-practice) do not measure up to ideal teaching strategies suggested in the current curriculum standard; current teachers consider that employing a problem-solving approach with the newer recommended curriculum is necessary and feasible; and to implement a problem-solving approach, current teachers have to strengthen their own pedagogical and technical skills and adapt instructional activities as well as facilities and equipment. (Contains 17 references.) (KC)

Running head: PROBLEM-SOLVING

Problem-solving As Intent and Content of Technology Education

Lung-Sheng Steven Lee
National Taiwan Normal University

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Abstract

This paper addresses the following three questions: (1) Why should problem-solving be the intent and content of technology education? (2) How can a problem-solving approach be incorporated into technology education programs? (3) What must be done to implement a problem-solving approach in the junior-high-school technology education programs in Taiwan? Problem-solving has often been equated with intelligence. Based upon the premises that intelligence, a set of thinking and learning skills, can be taught and that technology is a human adaptive system, technology education should urge problem-solving as its *intent* to enable students to become practical problem-solvers and as its *content* to integrate a problem-solving process throughout all the instructional content. It has also been found that more research and development efforts should be made to comprehend how to effectively employ problem-solving approach in technology education programs. In addition, a study completed in Taiwan found: (1) There is an obvious distinction among the key instructional strategies which were separately suggested in the current IA curriculum standard and the new LT curriculum standard. (2) The instructional strategies which current IA teachers actually use, commonly lecture-demonstration-practice, do not measure up to the ideal strategies suggested in the current IA curriculum standard. (3) Current IA teachers consider that employing a problem-solving approach in LT is necessary and feasible. (4) To effectively implement a problem-solving approach, current IA teachers have to strengthen their own pedagogical and technical skills, and adapt current instructional activities as well as facilities and equipment.

Problem-solving As Intent and Content of Technology Education

A model of a problem can be illustrated as shown in Figure 1. A problem exists when "what is" is not the same as "what is desired." Problem-solving (PS) begins by recognizing that a situation needs resolution, which cannot be determined by habit or by lack of thoughtful consideration. Practical problems are concerned with action based on thought, and theoretical problems are only related to thought (Brown, 1976). Human beings have always been faced with a variety of practical problems and have always tried to solve them. Once a practical problem is solved, the solution seems obvious, but a new problem often comes on quickly. To cope with these problems and find ways to adapt both our natural and man-made environments, everyone needs flexible, critical, and creative thinking skills. Thus, practical problem-solving is often considered to be synonymous with creative problem-solving.

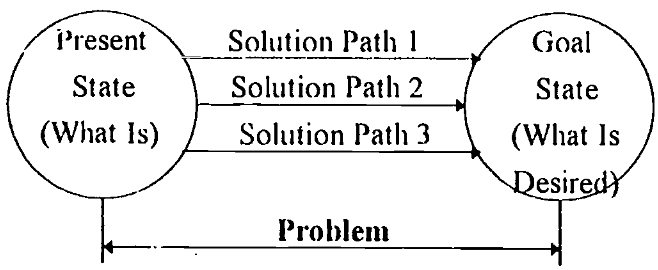

Figure 1. A Model of A Problem.
Source: Slightly adapted from Rubinstein & Pfeiffer, 1980, p.32.

As depicted in the problem-solving process wheel (Figure 2), problem-solving is seen as a sequence of successive phases of divergent thinking followed by convergent thinking, and is assumed to have the following six distinct steps: (1) identifying a problem--to clearly understanding the exact nature, specifications, and desired results of the problem; (2) gathering information--to collect as much information about the problem as possible, and then to analyze the data and condense it to its main causes or factors; (3) developing solutions--to use divergent thinking to get as many alternative solutions as possible; (4) selecting solutions--to utilize convergent thinking to find the best solution for implementation ; (5) implementing solution--to try out a solution and obtain some actual results; and (6) evaluating results--to evaluate the actual results and make necessary modifications (Hacker & Barden, 1988; Johnson, 1987; Lumsdaine & Lumsdaine, 1995; Naughton, 1994; Newman, 1995; Wright, 1992). Apparently, a problem-solving process employs many different higher-order thinking skills or intellectual processes such as creative thinking, cooperative dialectical process, critical thinking, and decision making (Laster, 1987a).

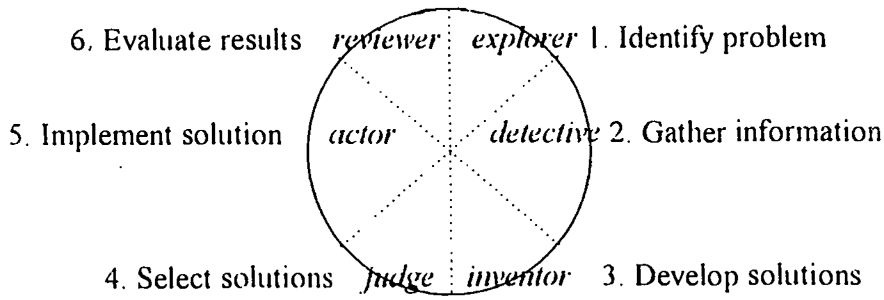

Figure 2. Problem-solving Process Wheel and the Problem-solver's *Roles*.

This paper addresses the following three questions: (1) Why should problem-solving be the intent and content of technology education programs? (2) How can a problem-solving approach be incorporated into technology education programs? (3) What must be done to implement a problem-solving approach in the junior-high-school technology education in Taiwan?

Why Should Problem-solving Be the Intent and Content of Technology Education?

Technology is considered to be a body of knowledge of the technical means whereby human beings adapt their environment to satisfy their needs and or desires. As a result, technology education has become a problem-oriented field, in which the nature of its knowledge base is generated by concern with an area of human beings' practical problems, and students are encouraged to become practical problem-solvers.

At the risk of oversimplification, the three categories of curriculum theories--positivism theory/social reproduction, phenomenology theory/human development, and critical theory/social reconstruction--can be linked to different concepts of the learner/student, society, subject matter, the controlling aim of education, and the generalized method in education as shown in Table 1. Our school systems have tended to emphasize the perspective of culture reproduction. Guided by this perspective, our students have been taught the "cookbook or recipe" methods (i.e., plug and chug approach) of problem-solving. Living in a very complex and ever changing world, we need flexible, critical, and creative thinking skills to cope with these problems and adapt our environment (Lumsdaine & Lumsdaine, 1995). Thus, the perspective of human development is considered to be very justifiable. Guided by this perspective, the curriculum should enable

Table 1.
A brief introduction to the concepts of the three categories of curriculum theories

	Categories		
	Positivism Theory/ Cultural Reproduction (learning in order to reproduce the existing culture)	Phenomenology Theory/ Human Development (learning in order to solve problems to meet individual needs)	Critical Theory/ Social Reconstruction (learning in order to change the existing society)
Learner	As a "potted flower" having certain facts and skills necessary to meet the expectations of society.	As a "wild flower", an independently creative and critical thinker, adequately responsible as a member of society, and an organism in continuity with nature.	As an "unfolding flower", developing his/her own uniquely individual qualities.
Society	Society and social conditions should be accepted and protected.	Social conditions and norms are not necessarily sound or unsound for human existence.	Society should provide a richness of stimuli and a pluralism of alternatives for personal self-selection.
Subject Matter	Subject matter consists of the accumulation of specific information.	Knowledge consists of both substance and processes.	All knowledge is subjective.
Con-trolling Aim of Education	Mastery of subject matter and specific skills within the subject matter.	Ability to use what is learned in autonomous critical thinking, problem-thinking, and action in a democratic society.	Finding the meaning of one's own existence and developing one's own potential.
General-ized Method in Education	Directive teaching and receptive learning with emphasis on subject matter.	Critical analysis, problem-solving, and democratic social processes.	*Laissez-faire*, non-directed learning environment for examination of one's own feelings, thoughts and for self-expression.

Sources: Brown, 1976; Zuga, 1992.

students "to use what is learned [through] autonomous critical thinking, problem-solving and action in a democratic society...to interrelate out-of-school life experience and school experience" (Brown, 1976, p. 12). That is to say, problem-solving should be the intent of the curriculum of technology, which is presented as a systematic human activity.

On the other hand, problem-solving has been and continues to be an integral part of technology education as well as other school subjects. There is a Chinese fable which explains the significance of processes of learning:

> A fairy pitied a beggar and pointed at a pebble to turn it into gold. However, the beggar shook his head when the fairy presented him with the piece of gold. The fairy then turned a stone into gold, but the beggar still shook his head. The fairy was very puzzled and asked the beggar whether the stone-size piece of gold was too small. The beggar replied, "Gold will be exhausted. I want not only the gold, but also your magic."

What the gold is to subject matter ("what" knowledge), magic is to method or processes of learning ("how to" or "what to do" knowledge). "['What'] knowledge is necessary, but not sufficient, for performance. Individuals vary not only in what they know, but in what they do with what they know" (Brown & Campione, 1982; cited in Laster, 1987a, p. 47).

Recent developments in cognitive psychology have conceptualized intelligence as a set of thinking and learning skills that can be modified (Laster, 1987a). In other words, it is proposed that intelligence, a set of thinking and learning skills, can be taught. To increase students' intelligence, the curriculum content should emphasize complex thinking processes, such as problem-solving, as well as established subject matter, and recognize the interaction of thinking processes and substantive content (Brown, 1976).

To sum up, technology education, centering around technology concerned with technical means to adapt our natural and man-made world, has become a problem-oriented field. Since our world is very complex and ever changing, problem-solving should be increasingly emphasized in technology education to enable our students to become problem-solvers. To achieve this goal, problem-solving processes should be incorporated with substantive technical content into technology education programs.

How Can A Problem-solving Approach Be Incorporated into Technology Education Programs?

It has been stated in the "Standards for Technology Education Programs" that "Emphasis is placed upon developing student problem-solving and decision-making abilities involving human and material resources, processes and technological systems" (Dugger, Bame, & Pinder, 1985, p.16). Therefore, promotion of students' problem-solving skills is one of the major purposes of technology education. Generally, there are three alternative ways or models for teaching students an emerging issue in a school: (1) establish a new separate subject for this issue, (2) infuse this issue into several existing subjects, and (3) integrate this issue into all existing subjects. As a comprehensive action-based educational program, technology education has instructional content drawn from one or more than one technology areas such as bio-related technology, communication, construction, manufacturing, and transportation. Consequently, what technology education is to the whole school curriculum, those technology areas are to the school curriculum subjects. As a key thinking skill students should learn and apply, problem-solving should be integrated throughout all the technology areas or instructional contents. The universal problem-solving process is illustrated in Figure 2, but Rubinstein and Pfeiffer (1980) pointed out the following common failings in problem-solving: (1) difficulty in isolating the problem; (2) associational constraints--making inappropriate associations to problem elements; (3) functional constraints--seeing problem elements as having only their usual function; (4) habitual constraints--the tendency to repeat an already successful solution path; (5) perspective constraints--the inability to see the problem from other than the view-points of others or a restricted perspective; (6) cultural, emotional, and environmental constraints; (7) failure to use all relevant information--due to limited memory, or stereotyping, or other forms of bias; and (8) using an inappropriate representation.

To integrate a problem-solving approach into technology education programs to emphasize the interaction of the problem-solving process and substantive technical content, the following criteria should be met:

1. Expectations for developing problem-solving skills are clear to students. Attitudes toward learning and learning is more likely to continue when students know what they are expected to learn and why.
2. Learning conditions for developing problem-solving skills are provided. Students should be encouraged to increasingly participate, mentally and physically, in identifying and solving a wide range of technology-related problems, including well-structured, semi-structured, and ill-structured problems.
3. Key practical communication and social skills are taught. A sequence of divergent and convergent thinking skills involved in the problem-solving process usually comprises some necessary communication and social skills such as brainstorming, collaboration, and compromise. These skills should be taught if students do not demonstrate them.

4. Appropriate representations are utilized.
   The problem-solving process can more likely be maintained if some well-designed representations such as a design brief and problem-solving guide sheet are employed.
5. The realities of everyday technology-related problem-solving are reflected in the learning environment.
   Students will be more eager to learn and will more easily apply what they have learned if the learning situation is or seems real. Thus, the practical and technology-related problems students encounter or will face at the present or in future everyday life should be experienced in the learning environment.
6. Individual learning styles and developmental needs are accommodated.
   Adaptive instructional strategies should be employed to ensure every student of a successful learning opportunity. (Hatch, 1988; Laster, 1987a, 1987b; Spitze, 1980)

Having reviewed the research literature from 1987-1993 in the field of technology education, Zuga (1994) states that problem-solving has been endorsed as a core instructional strategy for technology education, but that research on problem-solving as a strategy for instruction has just begun. This has led to a deficit in the amount of knowledge about whether technology education is meeting the goal of problem-solving instruction or whether it is a reasonable goal, and suggests that we need more research and development efforts to better understand and justify problem-solving approaches for technology education programs.

What Must Be Done to Implement A Problem-solving Approach in the Junior-high-school Technology Education Programs in Taiwan?

According to the future curriculum standard, which has been updated and promulgated by the Ministry of Education, the required junior-high-school subject "industrial arts" (IA) in Taiwan will be replaced by "living technology" (LT) in 1997 (Lee, 1994 & 1995). In the new curriculum standard, the problem-solving approach will apparently be suggested as a key instructional strategy of LT. With funding by the National Science Council (NSC), the author and his research assistants completed a study entitled "Current and Anticipated Instructional Strategies for Junior-high-school Technology Education" in 1995 (Lee et al., 1995) . The purposes of that study were to explore: (1) the distinctions between the two key instructional strategies which were separately suggested in both the current IA and the new LT curriculum standards, (2) the instructional strategies which current IA teachers had been commonly employing, (3) the possibility of implementing the problem-solving approach in future LT, and (4) the efforts which will need to be made to widely and effectively implement the problem-solving approach.

Through a literature review, in-depth interviews with 10 junior-high-school IA teachers, three classroom observations along with videotaping analysis, and triple expert conferences, the study reached the following four conclusions:

1. There is an obvious distinction among the key instructional strategies which were separately suggested in the current IA curriculum standard and the new LT curriculum standard.
   The project method and instructional techniques comprising depiction, lecture, demonstration, Q&A and practice were obviously suggested in the current IA curriculum standards while problem-solving, consisting of diversified instructional techniques, is suggested in the new LT curriculum standard.
2. The instructional strategies which current IA teachers actually use do not measure up to the ideal strategies suggested in the current IA curriculum standard.
   The trilogy of lecture, demonstration, and practice is widely used in current IA classrooms/labs.
3. Current IA teachers consider that employing the problem-solving approach in LT is necessary and feasible.
   All current IA teachers interviewed and conferenced with in this study praised the problem-solving approach; saying that it can be and should be strengthened in the coming junior-high-school LT curriculum.
4. To effectively implement the problem-solving approach, current IA teachers have to strengthen their own pedagogical and technical skills, and adapt current instructional activities, as well as facilities and equipment.
   Problem-solving is thorough and takes time. Students need project problems, teachers' guidance, sufficient time, open-ended equipment, et al., to cope with, incubate, think about and solve a problem. It is found that to provide these things, diversified problem-oriented technology learning activities (TLA's) should be developed as early as possible, and in-service IA teacher workshops on problem-solving should be conducted.

Summary

Problem-solving, a complex cognitive thinking skill, is critical for dealing with the realities of our very complex and ever changing world. To present technology as an human adaptive system, a technical means, praxiological knowledge, or a systematic activity, technology education should have problem-solving as its intent and content. To achieve this goal, the problem-solving process should be integrated throughout all the technology areas and instructional contents. However, it is found that more research and development efforts should be made to better comprehend how to effectively employ the problem-solving approach in technology education programs. Based on the findings of this study, we suggest that to effectively implement the problem-solving approach in future junior-high-school technology education programs, current industrial arts teachers have to strengthen their own pedagogical and technical skills, and adapt current instructional activities as well as facilities and equipment.

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Author Note

Dr. Lung-Sheng Steven Lee is a professor and the Department Chair of the Department of Industrial Technology Education at National Taiwan Normal University, and the Secretary General of the Chinese Industrial Arts Education Association (CIAEA). Correspondence concerning this paper should be addressed to Lung-Sheng Lee, Department of Industrial Technology Education, National Taiwan Normal University, 162 Hoping E. Rd., Sec. 1, Taipei 106, Taiwan, R.O.C. Electronic mail may be sent via Internet to t83006@cc.ntnu.edu.tw.